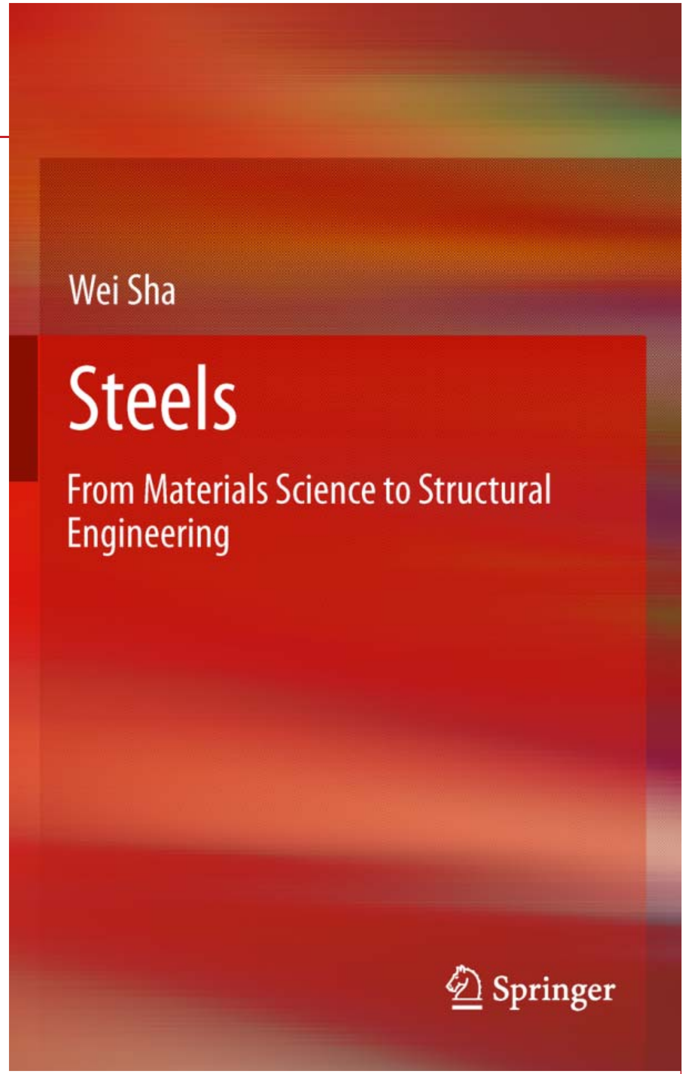
Design optimisation of steel portal frames

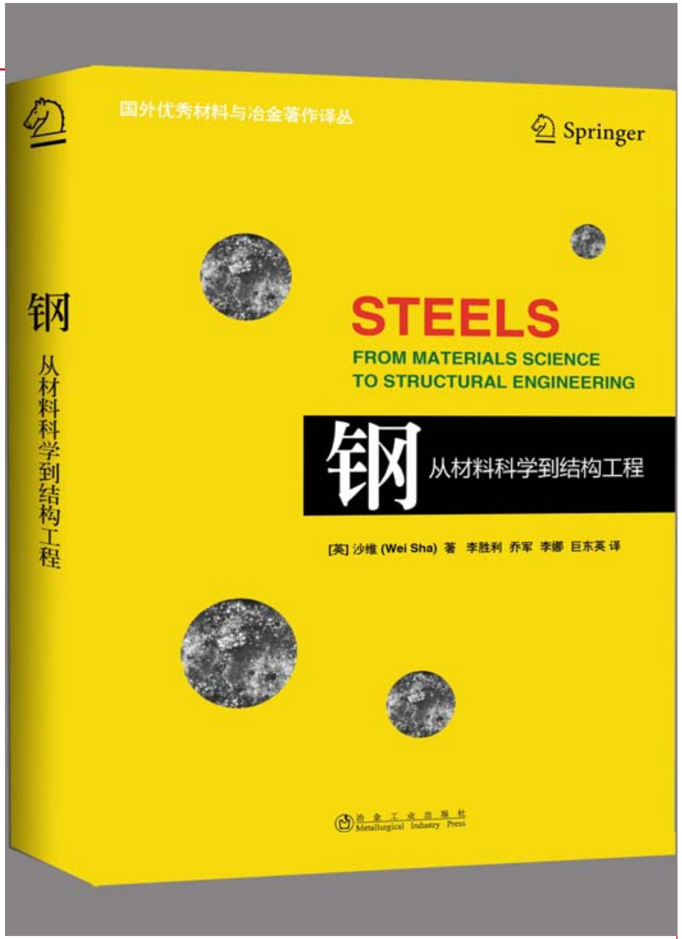
Materials Science
PhD projects in progress

- Microstructure, tribological and electrochemical corrosion behaviour of electroless Ni-P-SiC coatings on aluminium for cylinder liner applications
- The development of eco-friendly and cost-effective geopolymer concrete
- Development of shape-stable phase change material with improved thermophysical properties
- The potential use of novel cements of lower pH for the safe encapsulation of waste aluminium



Structural Engineering
PhD projects in progress

- Sustainable design optimisation of single storey steel buildings
- Web crippling behaviour of cold-formed steel and stainless steel channel sections with web openings

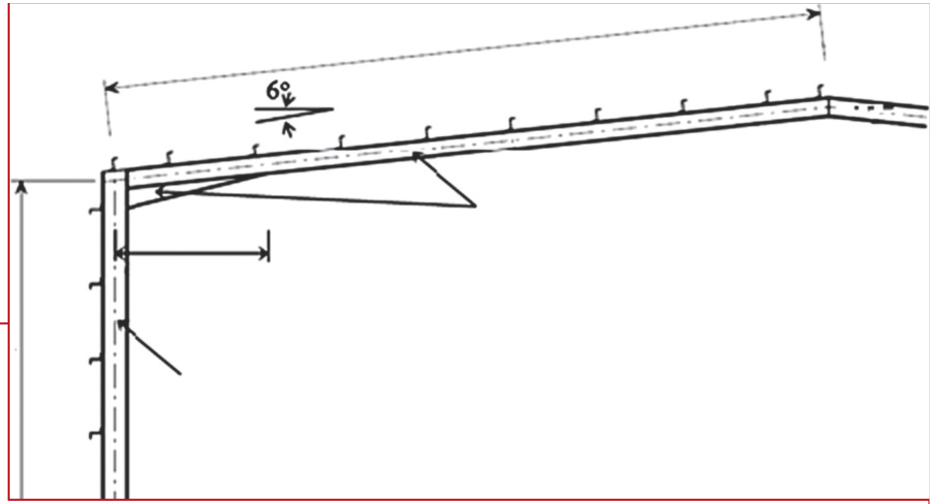


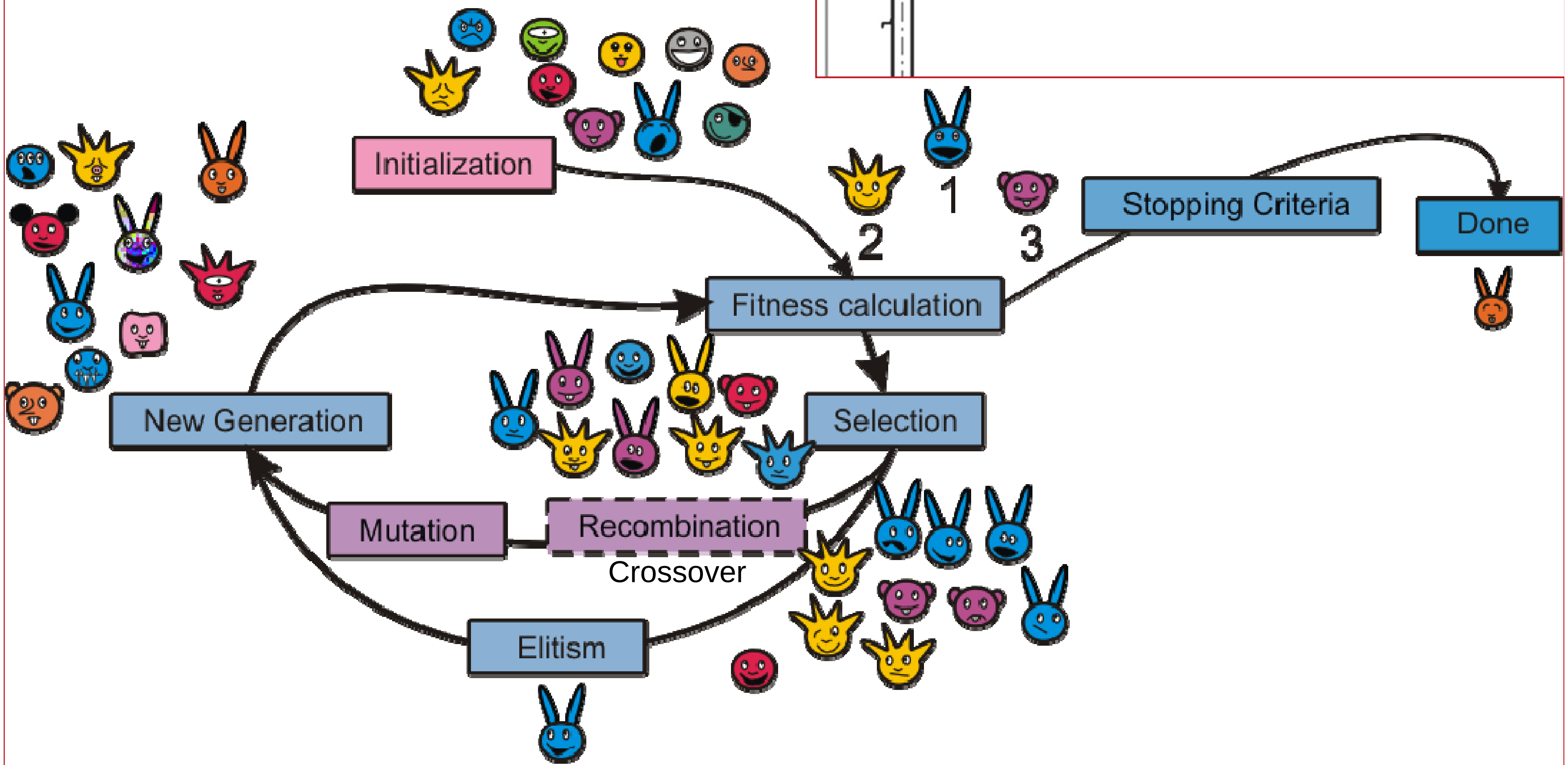
Design optimisation of steel portal frames

Wei Sha

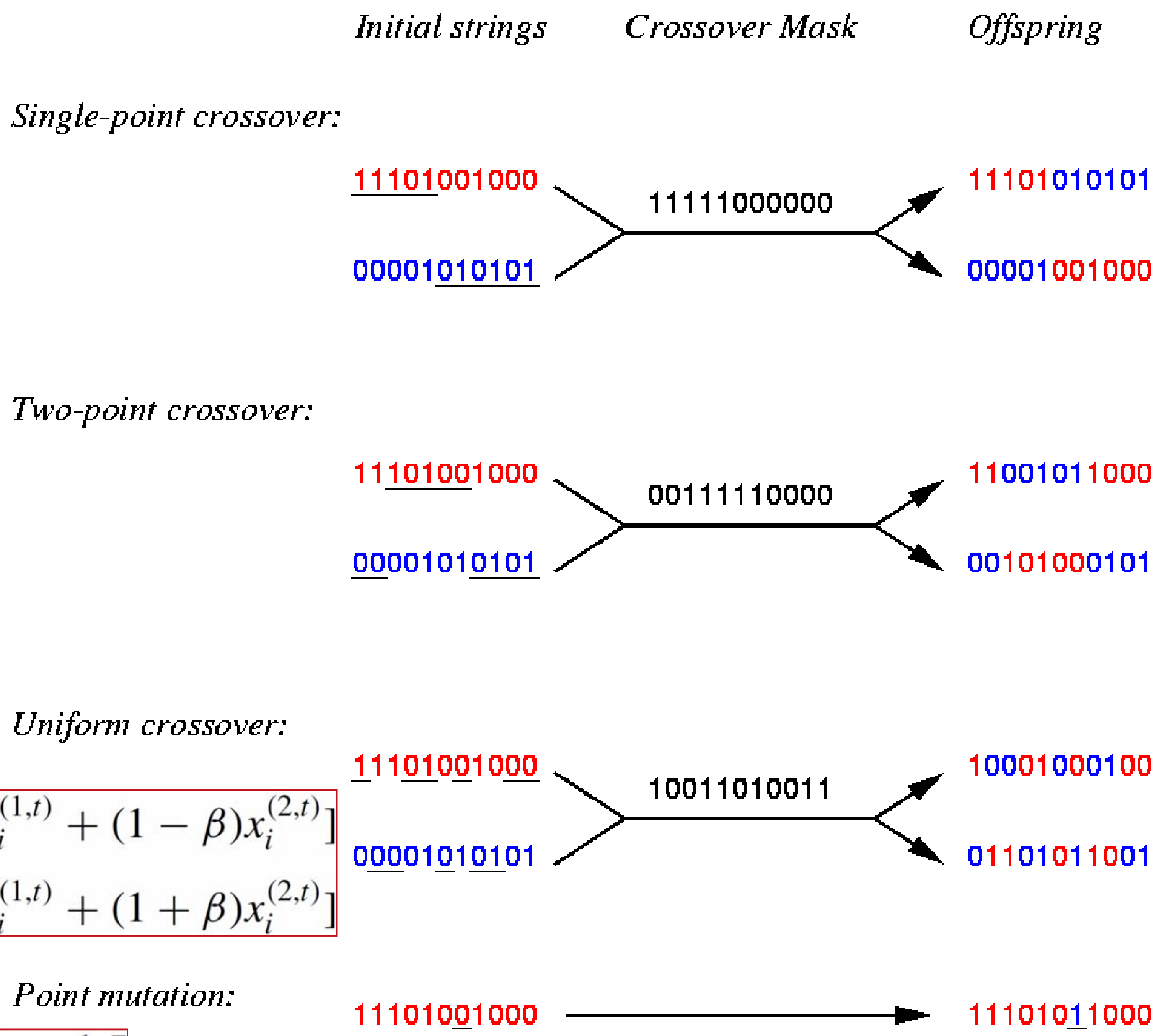

column
rafter
purlins
side rails
cladding
eaves haunch
apex haunch
Google Images “steel portal frame buildings uk”

Genetic algorithm





Journal of Constructional Steel Research, **86**, 2013, 74-84.

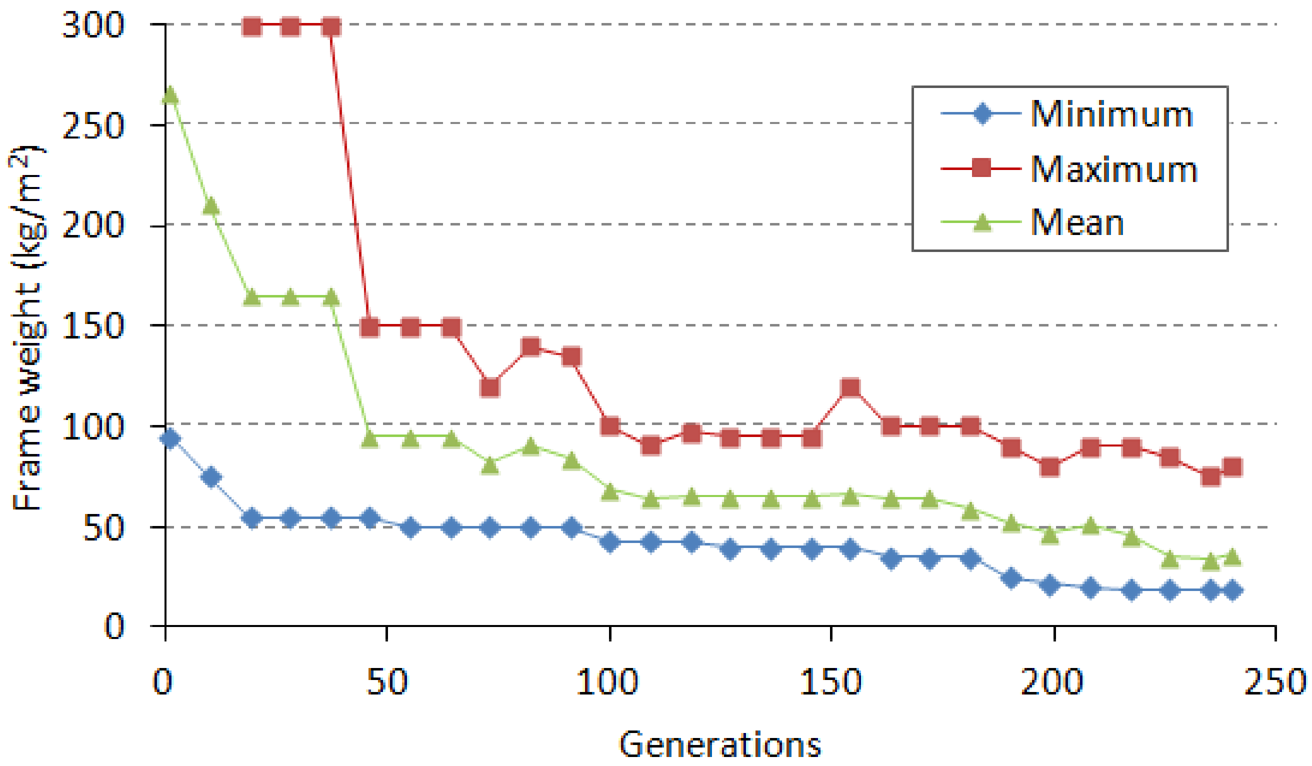


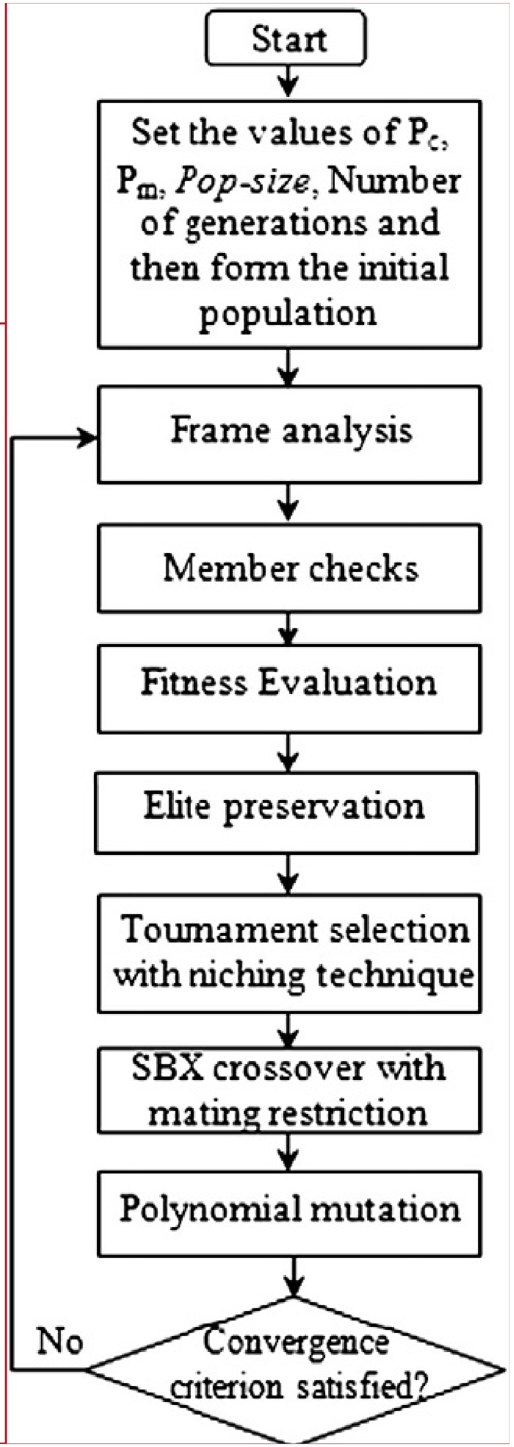
$$x_i^{(1,t+1)} = 0.5[(1+\beta)x_i^{(1,t)} + (1-\beta)x_i^{(2,t)}]$$
$$x_i^{(2,t+1)} = 0.5[(1-\beta)x_i^{(1,t)} + (1+\beta)x_i^{(2,t)}]$$

$$y_i^{(1,t+1)} = x_i^{(1,t+1)} + (x_i^u - x_i^l)\bar{\delta}$$

Engineering Optimization, **45**, 2013, 415-33.

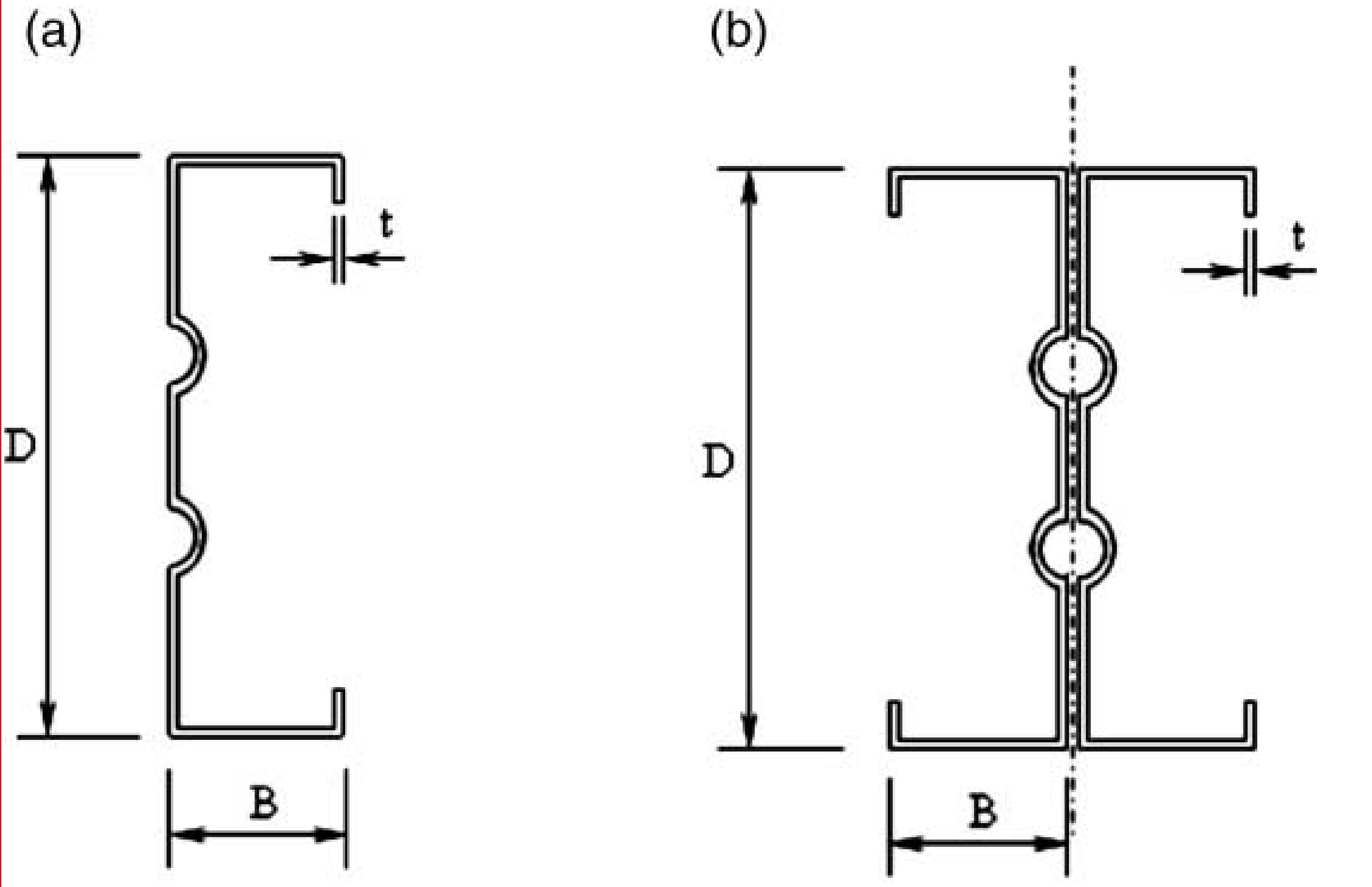
Flowchart and convergence

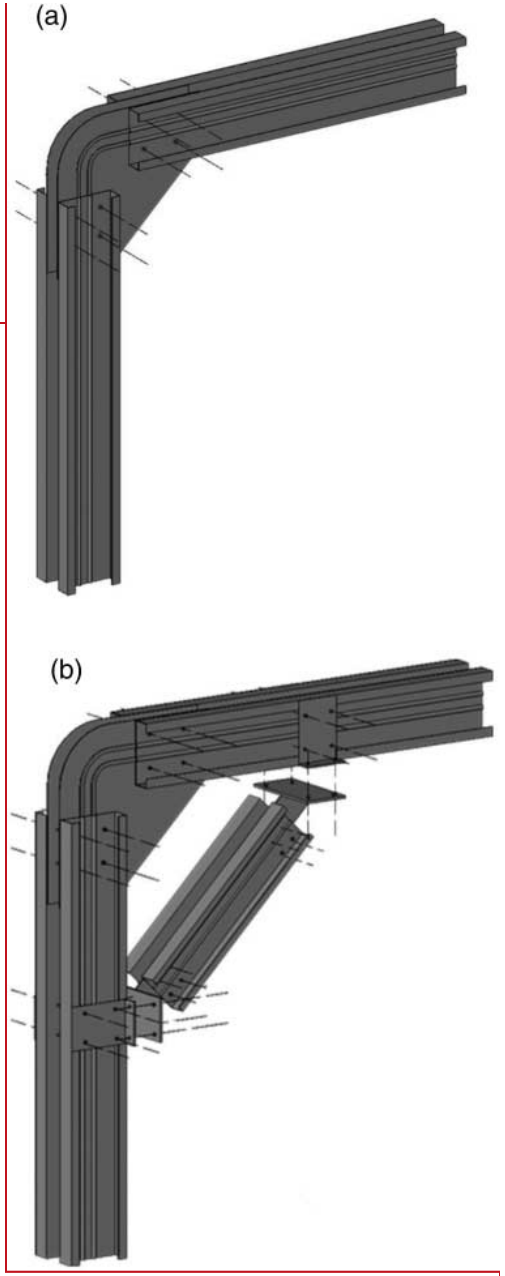




J. Constr. Steel Res., **86**, 2013, 74-84.

Cold-formed steel portal frames





Twenty-First International Specialty Conference on Cold-Formed Steel Structures, St. Louis, Missouri, 2012, 485-97.

Topography optimisation

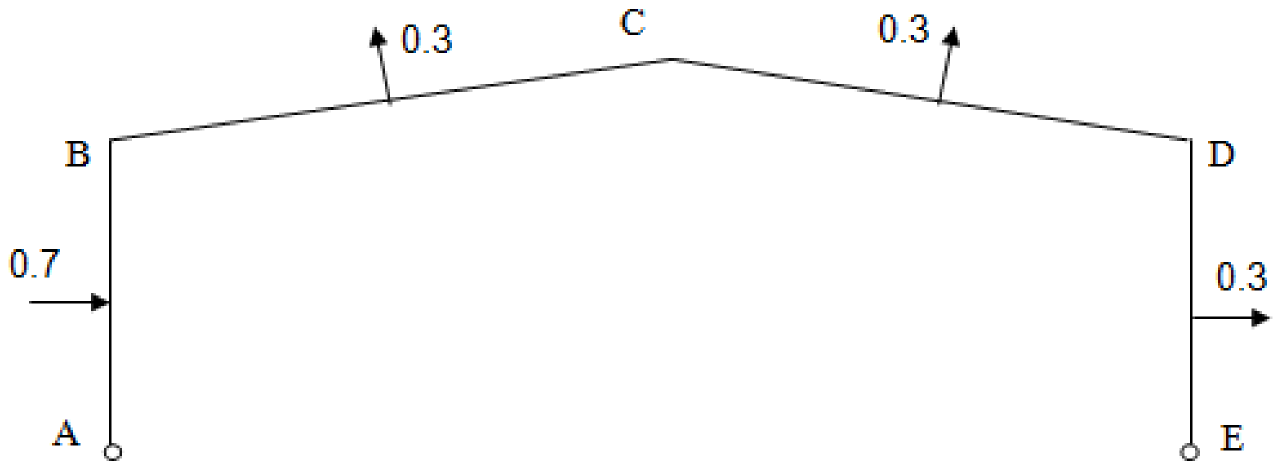
1: Geometries and section sizes for three exemplar frames 10°, 4 m

Frame	Span (m)	Height (m)	Section sizes for unit weight (kg/m)			Section sizes for unit cost (AUD/m)		
			Column section	Rafter section	Unit weight	Column section	Rafter section	Unit cost
A	15	3	BBC30030	BBC30030	135.46	BBC30030	BBC30030	384.82
B	20	4	BBC30030	BBC30030	180.60	BBC30030	BBC30030	513.34
C	25	5	BBC35030	BBC35030	269.46	BBC35030	BBC35030	791.60

2: The result of optimum solutions for three exemplar frames

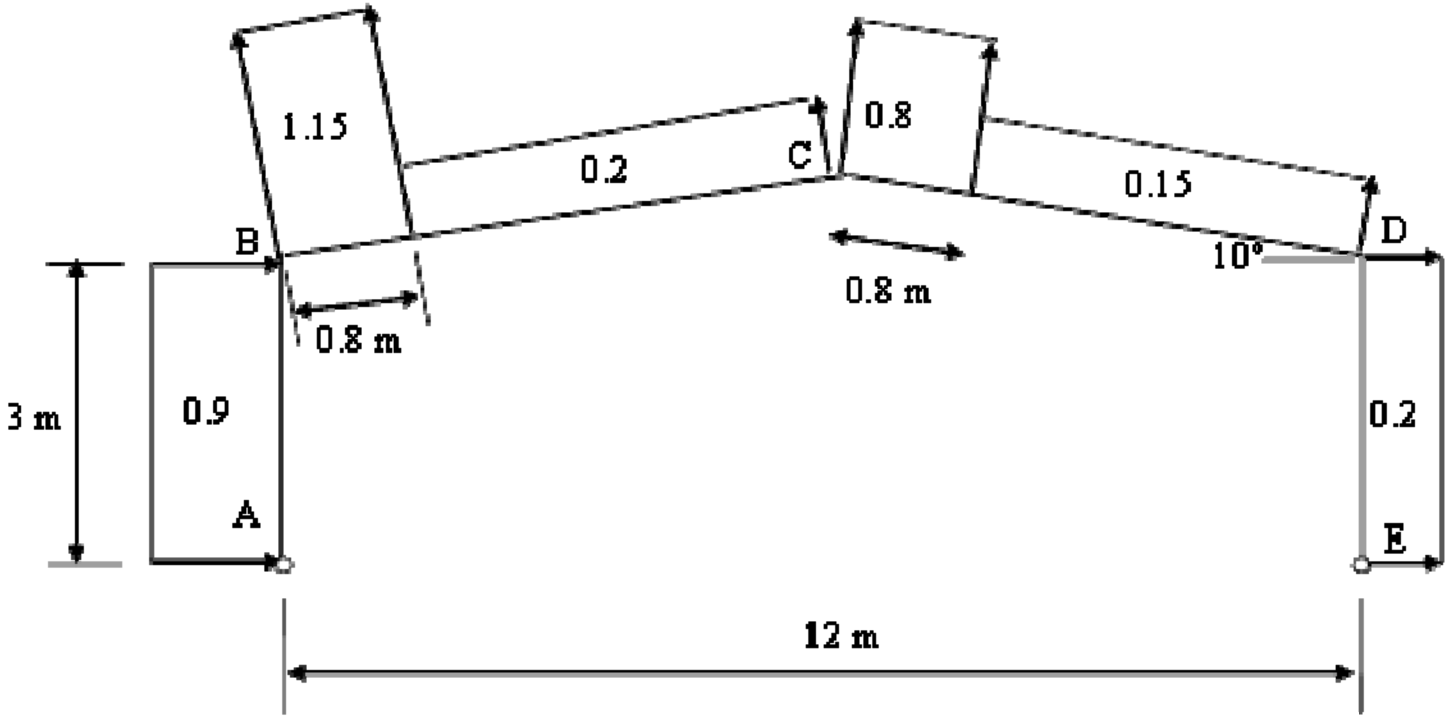
Frame	Span (m)	Height (m)	Pitch (degree)	Bay spacing (m)	Wind pressure (kN/m^2)	Column sections	Rafter sections	Unit cost (AUD/m)
A	15	3	21	3.17	1.45	BBC25024	BBC25024	248.19
B	20	4	21	2.95	0.91	BBC25024	BBC25024	355.60
C	25	5	20.9	2.16	0.68	BBC25024	BBC25024	606.80

Procedia Engineering, **14**, 2011, 724-33.



Australian coefficients of wind pressure for wind load combination 1.

8 combinations.



British coefficients of wind pressure for wind load combination 1.

6 combinations.

Steel and Composite Structures, **15**, 2013, 519-38.

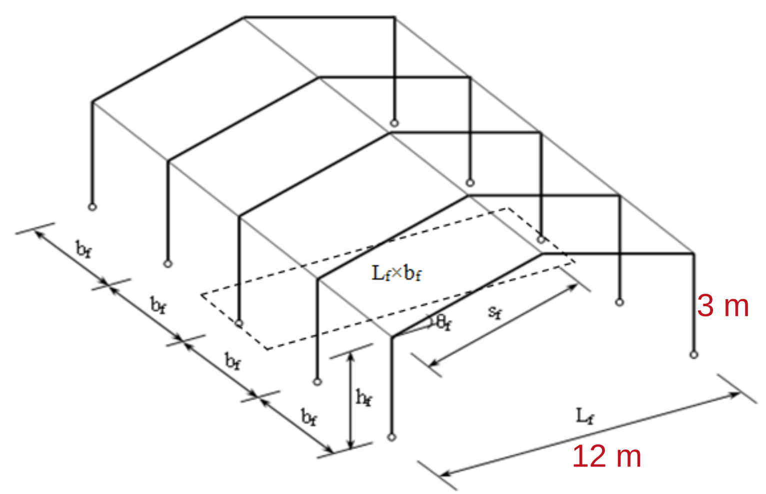
Cost

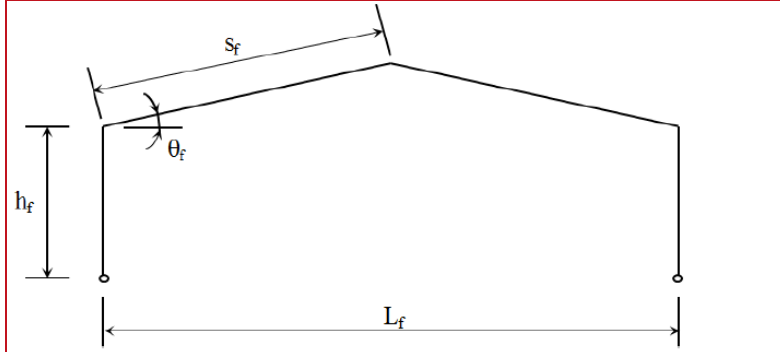
Hot or cold?

Table 9 Cost of Reference Frame

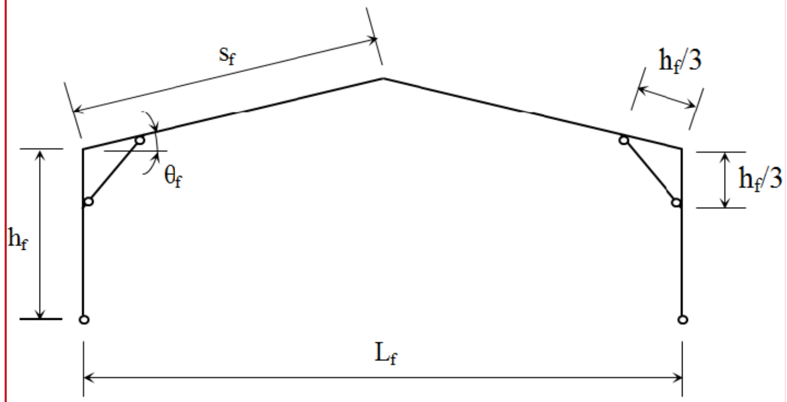
Type	Topology	Main frame (£/m²)
Hot-rolled steel	Fixed	6.60
Type 1	Fixed	6.59
Type 1	Variable	5.60
Type 2	Fixed	6.20
Type 2	Variable	4.70

Thin-Walled Structures, under review.



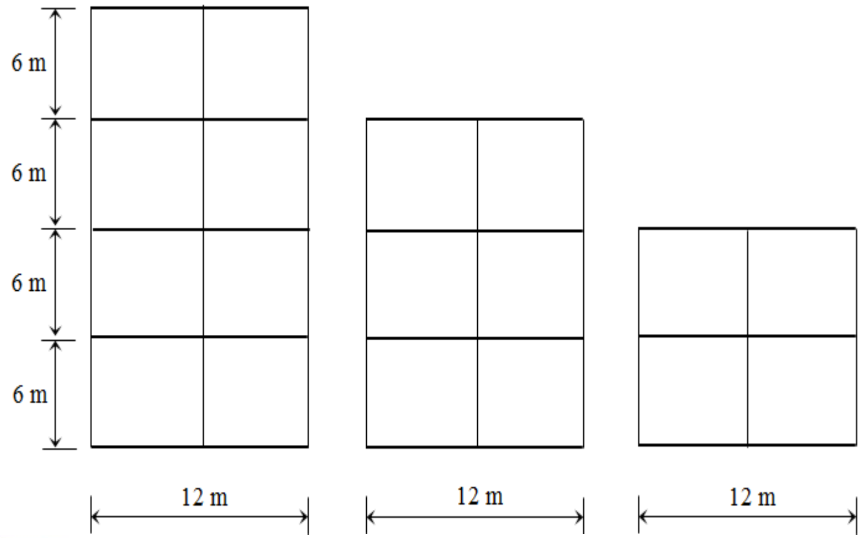


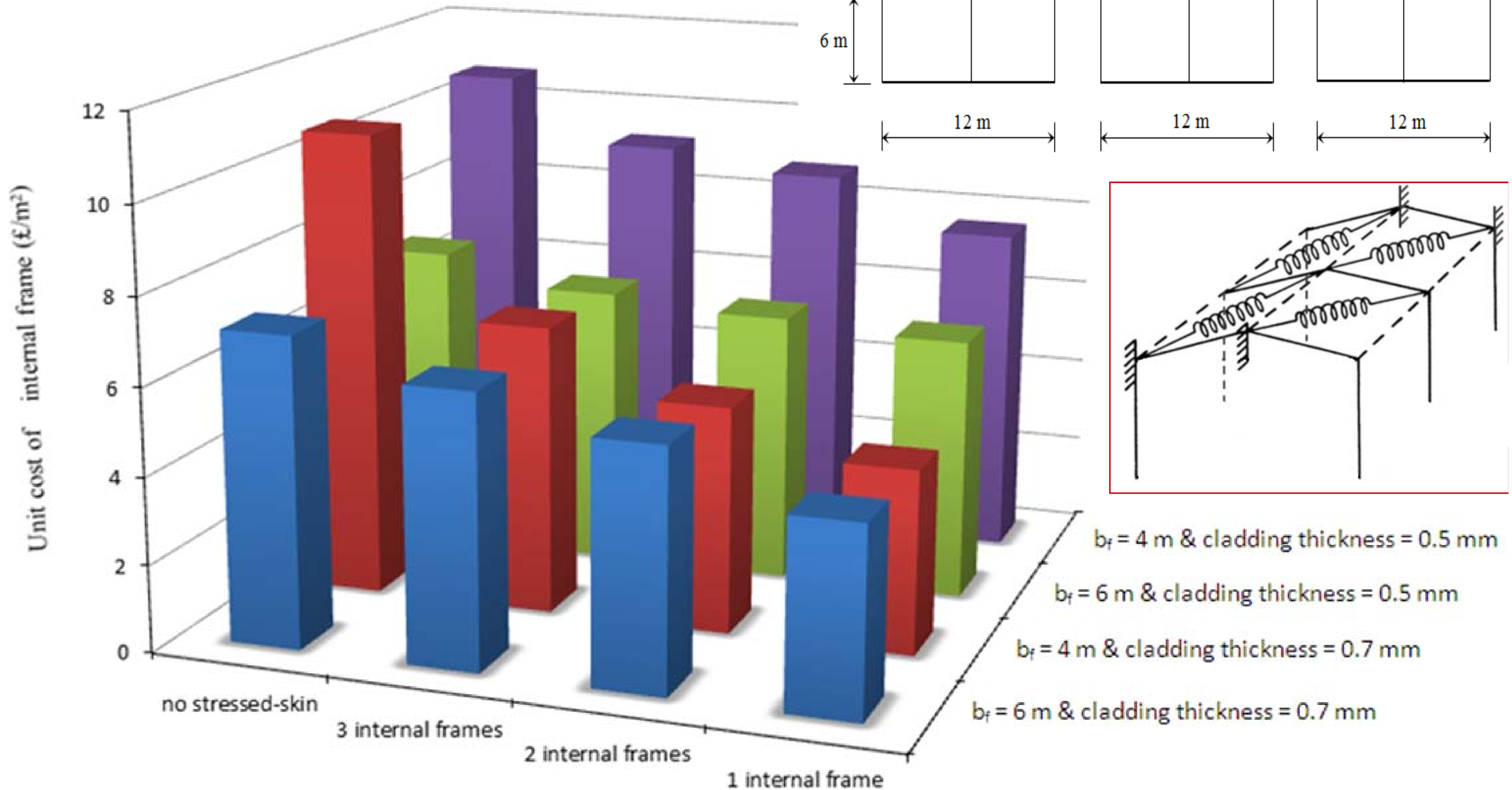
(a) Type 1: Rigid-jointed frame



(b) Type 2: Rigid-jointed frame having knee braces at the eaves

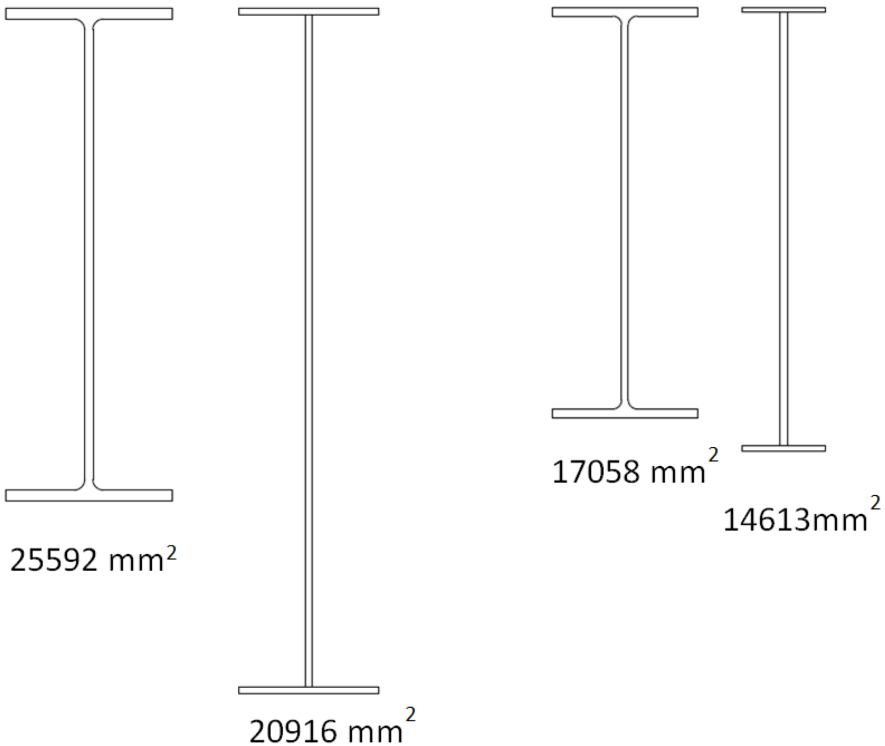
Stressed-skin
Cost of internal frames





PhD thesis: Duoc Phan. KTP with Capital Steel Buildings

Optimal design of long-span steel portal frames using fabricated beams to Eurocode 3



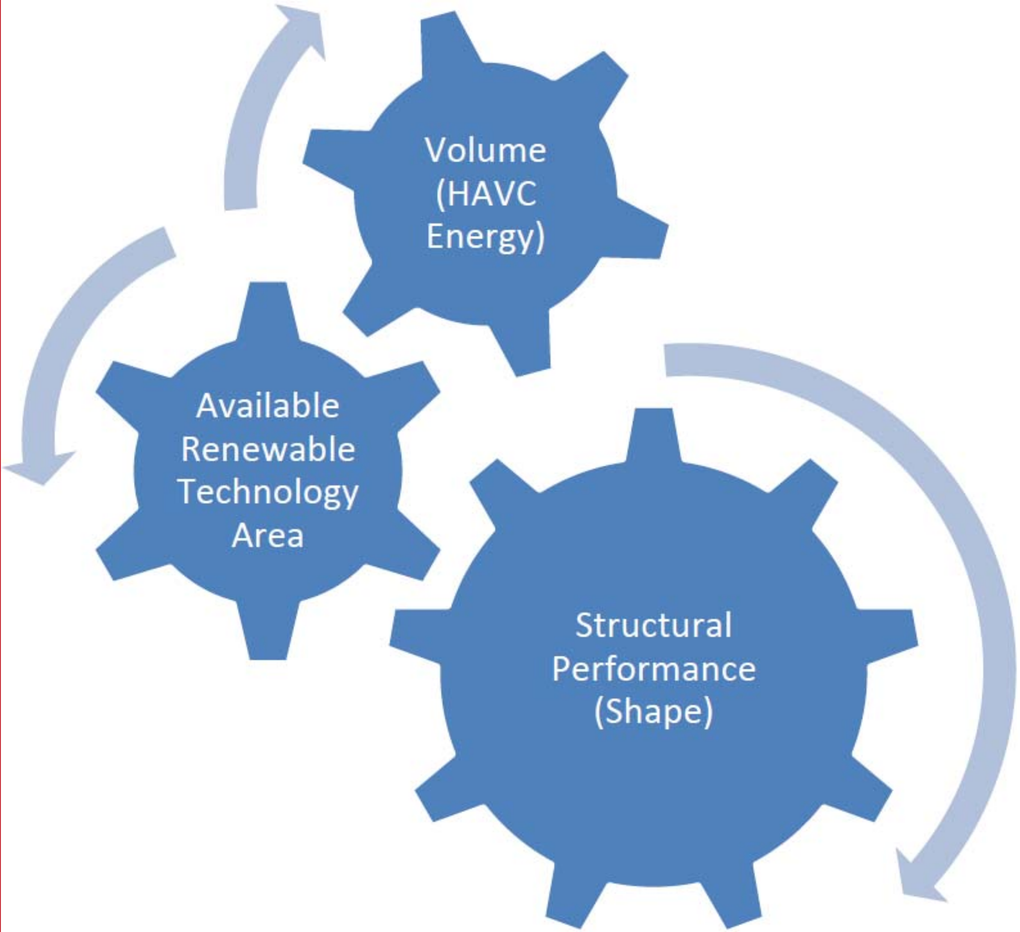
Column

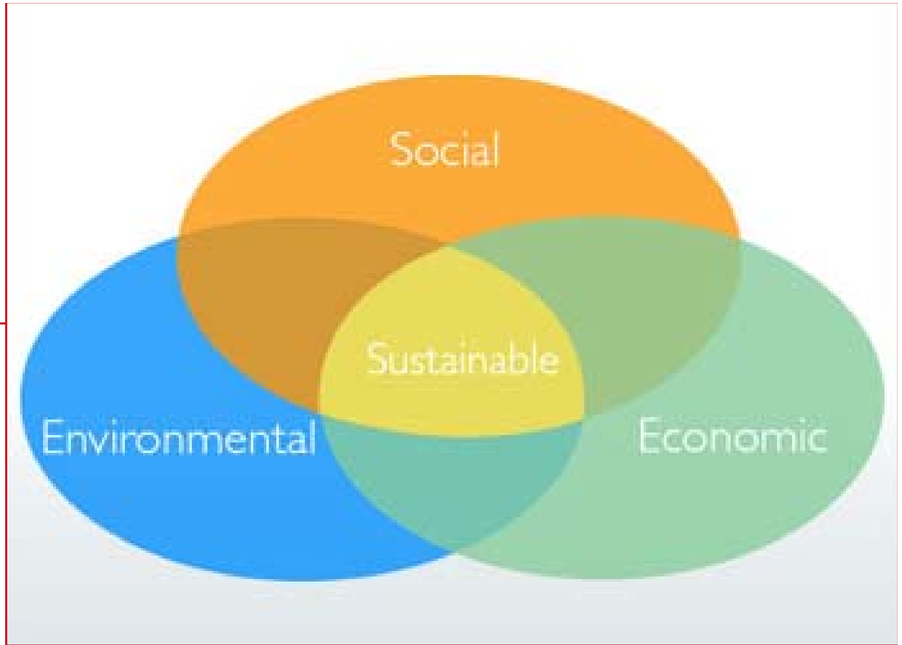
Rafter

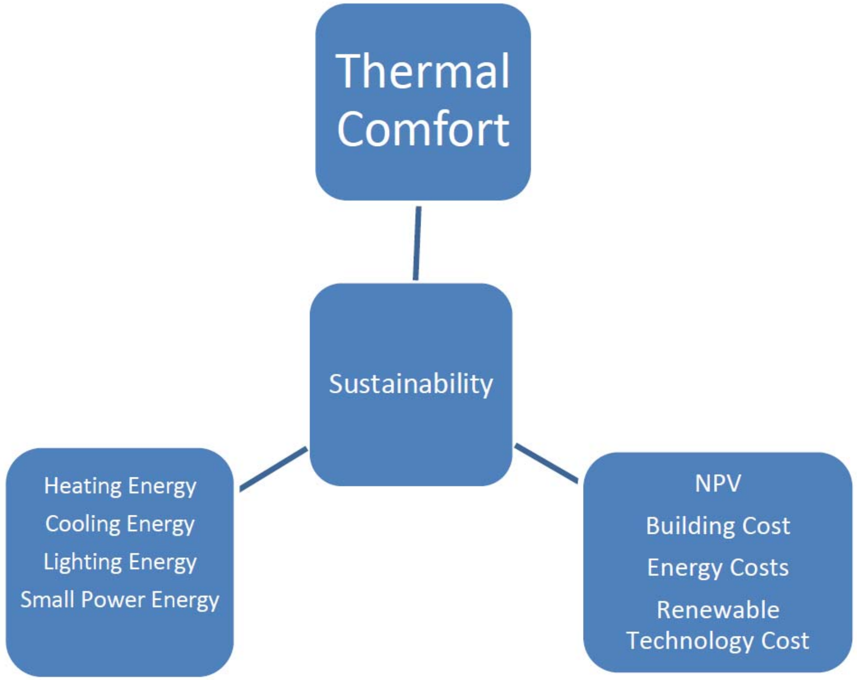
35% saving

Journal of Constructional Steel Research, submitted.

Potential GA objectives

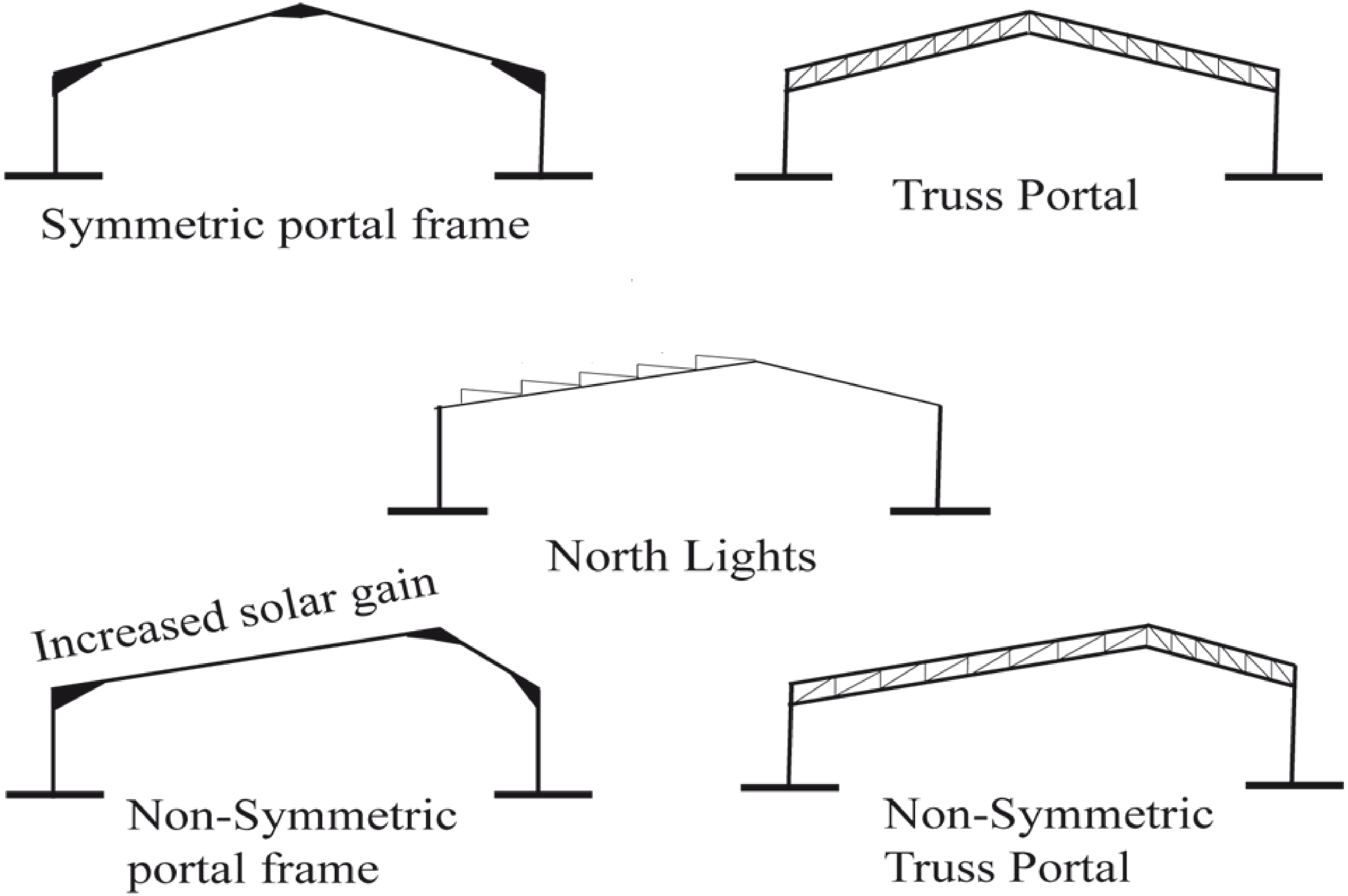






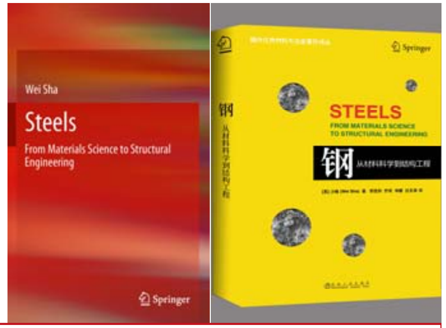
PhD student: Ross McKinstray. KTP with Ostick+Williams

Design options



PhD student: Ross McKinstray

Acknowledgements



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